DYNAMIC TIME MULTIPLEXED HOLOGRAPHIC SCREEN WITH 3-D PROJECTION

This application claims the benefit of provisional application 60/223,134 filed Aug. 7, 2000.

BACKGROUND OF THE INVENTION

1. Field of Invention

The present invention is directed to the field of three-dimensional (3-D) displays. More particularly, the present invention concerns 3-D displays that do not require the viewer to wear goggles or glasses.

2. Description of Related Art

Presently, most 3-D systems rely on visual channel separation, either by orthogonal polarization states to represent left and right images, shutters to synchronize the display with goggles, or red/blue color coding. In stereoscopy, the left and right eye viewing channels are fused by the viewer into a 3-D view of the world. There are a few stereoscopic systems that produce 3-D images without any headgear, but they suffer severe limitations. Real 3-D displays based on volumetric projection, as from a spinning display screen, can show correct perspectives to multiple viewers, but are inherently limited in resolution and image refresh speed, since they require every point in the volume (every pixel) to be modulated and displayed sequentially.

Still other prototype displays based on conventional static holograms or laser illumination of spinning objects cannot produce satisfactory imaging. Because these displays, based on differential polarization, require lengthy preparation of several perspective views of the scene, such as heavy computations and special formatting, they are not suited for real-time applications.

Stereo vision is based on the perception of depth. Stereo display systems are based on the most dominant depth cue (i.e., parallax), which is defined as the angular separation between corresponding points of left and right perspective images. In this respect, human 3-D vision does not require "real" 3-D information, since the human brain encounters only two 2-D retinal images, neither of which preserve z-axis (i.e., depth) information. This third dimension is reconstructed only in the brain. Therefore, 3-D displays can be based on capturing and displaying a 2-D left image and a 2-D right image in order to replicate the corresponding left and right retinal images.

As noted above, stereoscopic displays provide an observer with parallax depth cues. This is done by presenting each eye with a view of an object from a different perspective viewpoint. When the difference between these viewpoints approximates normal interocular separation, an impression of viewing an actual solid object is created. Conventionally, some form of viewing device, such as glasses, is required to channel a different view into each eye. This is quite effective in presenting a three dimensional impression, and it requires only twice the amount of image data compared to a two dimensional view. The major drawback is the need to wear a device or to peer into eyepieces. This has led to many years of effort to provide directly viewable (i.e., stereoscopic without glasses) or, more precisely, autostereoscopic images.

Autostereoscopic displays create a "window" through which an unaided observer can view what appears to be a solid object. This is a very natural and desirable situation from the standpoint of the observer, but involves two substantial technical challenges. First, the light rays leaving the display must be directed so that each of the observer's eyes receives a complete but different image. Second, images of the object from a range of viewpoints must be presented simultaneously. There may be as few as two perspective views, but typically four or more are required to provide a range of viewing positions (scenes). This greatly increases the amount of image data which must be managed.

Holographic displays and lenticular photographs are the most familiar examples of autostereoscopic images. Holographic displays (or holograms) are an interferometric pattern of a recorded object which can be reconstructed by a collimated beam.

Recently, considerable interest has been directed toward autostereoscopic techniques which are based on the multiplex carrier method. This approach is simple, practical, and low cost and provides a limited "look-around" 3-D effect if more than two perspectives are projected into the viewing eyebox. If the number of perspectives is low enough, images may be generated and displayed in real-time because the data processing demands can be satisfied. However, in this technique, the image projection area must be divided into two separate parts, which significantly reduces the image's spatial resolution. Further, this technique has additional drawbacks-because it requires sequential scanning of N perspectives (N>1) for each vertical scan line. The line feed rate R to the multiplexed monitor is related to the flicker-free line rate r by R=N×r. Thus, the feed signal rate is increased two or more times relative to the rate necessary for monocular monitor.

In sum, in many technical fields, 3-D displays can provide scientists and technicians with the ability to better interpret the physical parameters of an image being displayed. 3-D display techniques have been attempted in the past, but have suffered from the need for the observer to wear external devices, the loss of real-time display capabilities, a lack of full screen resolution, the need for heavy computation and special formatting, very high cost, and/or any combinations of the above. A truly practical device must be able to interface with conventional 2-D display systems in order to increase vendor acceptance, provide real-time capabilities for interactive applications, and provide 3-D look around capabilities without special viewing glasses. In addition, a cost effective production method must be established to make the device attractive for commercial markets.

The disclosures of all the below-referenced prior United States patents in their entireties are hereby expressly incorporated by reference into the present application for purposes including, but not limited to, indicating the background of the present invention and illustrating the state of the art. U.S. Pat. No. 3,479,111 discloses a three-dimensional picture projection. U.S. Pat. No. 4,799,739 discloses real time autostereoscopic displays using holographic diffusers. U.S. Pat. No. 4,926,412 discloses a high channel density wavelength division multiplexer with defined diffracting mean positioning. U.S. Pat. No. 5,365,354 discloses a GRIN type diffuser based on volume holographic material. U.S. Pat. No. 5,886,675 discloses an autostereoscopic display system with a fan-out multiplexer.

SUMMARY OF THE INVENTION

The present invention includes a holographic screen and a projector that projects successive perspective images onto the holographic screen. The projector can include a rotating polygon that provides successive image slices to the holographic screen and a spatial light modulator that provides